AGE OF ACQUISITION EFFECTS IN BILINGUAL WORD TRANSLATION

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AGE OF ACQUISITION EFFECTS IN BILINGUAL

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CHAPTER I

INTRODUCTION

Age of Acquisition Effects in Bilingual Word Translation

A person who knows more than one language has multiple memory representations for most everyday concepts. For example, a Spanish-English bilingual has two words to refer to a common table fruit used for making pies (i.e., *apple* and *manzana*). Prior research has investigated the degree to which the memory systems for a bilingual's languages are separate or interconnected (Altarriba, 1992; De Groot, Dannenburg, & Van Hell, 1994; Kolers, 1963; Kroll & Stewart, 1994; Potter, So, Von Eckhardt, & Feldman, 1984; Scarborough, Gerard, & Cortese, 1984). Several models of bilingual memory have been proposed. Some of these models have focused on the extent to which phonological representations are separate or shared (Dijkstra & Van Heuven, 1998; Green, 1998). Other models have focused on the extent to which semantic representations are separate or shared (De Groot, 1992; Dong, Gui, & MacWhinney, 2005; Grosjean, 1997; Kroll & Stewart, 1994). The purpose of the present research was to investigate semantic representations for a bilingual's two languages.

One of the most prominent models of bilingual semantic memory is the revised hierarchical model (RHM), proposed by Kroll and colleagues (De Groot & Kroll, 1997; Kroll & Curley, 1988; Kroll & Stewart, 1994). The RHM is composed of three memory components: 1) a conceptual representation store; 2) lexical representation for words in

one's first language (L1); and 3) lexical representation for words in one's second language (L2). As shown in Figure 1, in this model the memory link between L1 and conceptual representation is the strongest of the memory links. Memory links also connect the specific word forms of L1 and L2 to conceptual representations. According to Kroll and Stewart (1994), for the beginning bilingual, retrieving conceptual information for an L2 word requires processing of the L1 translation equivalent. As one's proficiency increases, the memory links between L2 and conceptual representation are expected to become stronger.

Kroll and Stewart (1994) provided support for the RHM in a series of translation experiments. Dutch-English bilinguals translated 144 Dutch and English words into the opposite language as translation times were recorded. Words were either presented in random order or blocked by semantic category. The semantic categories were weapons, vegetables, furniture, birds, clothing, fruits, animals, and vehicles. Two key findings were observed. First, participants took longer to translate Dutch words into English (i.e., L1 to L2) than to translate English words into Dutch (i.e., L2 to L1). Kroll and Stewart (1994) viewed this result as consistent with the RHM's prediction that lexical links from L2 to L1 words are stronger than the lexical links from L1 to L2. Second, participants took longer to translate Dutch words into English when they were blocked by semantic category than when they were presented in random order; no effect of order was observed when participants translated English words into Dutch. Kroll and Stewart (1994) described the longer response times in the blocked condition as *categorical inference.* Viewing multiple words from the same semantic category caused activation of all members of that category. This increased activation led to difficulties in word retrieval,

which resulted in slower translation times. Because memory links between the conceptual representation and L1 words are stronger than memory links between conceptual representation and L2 words, *categorical interference* occurred when participants translated from L1 to L2, but not when participants translated from L2 to L1.

CHAPTER II

REVIEW OF LITERATURE

SUPPORT FOR THE REVISED HIERARCHICAL MODEL

Since 1994, there have been numerous studies whose results were consistent with the RHM (see also Damian, Vigliocco, & Levelt, 2001; De Groot, 1992; Habuchi, 2003; Kroll & de Groot, 1997;-Sholl, Sankaranarayanan, & Kroll, 1995). In one of the most compelling studies, Sholl et al. (1995) hypothesized that participants' performance in a translation task could be influenced by a prior picture-naming task. In the study**,** English-Spanish bilinguals first performed a picture-naming task in which they were shown two blocks of pictures. For this task, participants named pictures using both of their languages. Following picture naming, participants translated words in both forward (i.e., L1 to L2) and backward (i.e., L2 to L1) directions. Half of the words in the translation task were the names of the pictures used in the previous task and half of the words had not been previously used. The results showed that when translating from L1 to L2, participants' response times were influenced by whether the concept had been previously experienced in the picture name task. Translation time was longest for words that had not been experienced previously in the picture-naming task. Translation time was shortest when a picture of the concept had been named in L2. Translation time was intermediate

when a picture of the concept had been named in L1. In conditions in which participants translated L2 words into L1, response times did not vary significantly across these three conditions. Sholl et al. (1995) argued that the picture-naming task increased activation among concepts, which led to interference during translation. Because memory links between the conceptual representation and L1 words are stronger than memory links between conceptual representation and L2 words, the interference occurred only when participants translated from L1 to L2, but not when participants translated from L2 to L1. Similar results have been reported by other authors (e.g., Cheung & Chen, 1998; Dong, Gui, & MacWhinney, 2005; Fox, 1996; Keatley, Spinks, & Degelder, 1994).

More recent studies have extended the framework of the RHM. Habuchi (2003) investigated the possibility that for bilinguals, memory links for concrete and abstract words differ in strength and in general, leading to processing differences for bilinguals when they translate L1 words into L2 and L2 words into L1. As pointed out by Paivio (1986), concrete words are words that refer to tangible objects, which are easily imageable. In contrast, abstract words are generally concepts that are not easily imageable. In Habuchi's (2003) experiment, Japanese-English bilinguals translated concrete and abstract words in both directions (i.e., L1 to L2 and L2 to L1). The results showed that participants were slower to translate concrete words than abstract words. Furthermore, participants took longer to translate L1 concrete words into L2 than they took to translate L2 concrete words into L1. Habuchi (2003) concluded that the results occurred because memory links between L1 words and conceptual representation are stronger than memory links between L2 words and conceptual representation.

Lastly, Silverberg and Samuel (2004) investigated the possibility that the strengths of memory links between conceptual representations and L2 words are related to the age at which L2 is learned. They compared the extent to which L1 and L2 words could activate from memory (i.e., prime) words belonging to the other language. They used the traditional priming task in which a prime word was following by a target word. Participants were instructed to judge as quickly as possible whether the target was a word or nonword. Prime words and target words were related in meaning or in orthographical form. Three groups of bilingual participants were tested: 1) highly proficient bilinguals who had learned the L2 before the age of seven; 2) highly proficient bilinguals who had learned L2 after the age of seven; and 3) less proficient bilinguals who had learned L2 after the age of seven. The results indicated that semantic priming effects between L2 and L1 words was influenced by bilinguals' level of proficiency, which was presumably related to the strength of the memory links between the conceptual memory and L2. Significant effects of priming were observed for both groups of highly proficient bilingual. More priming was observed for those who had learned L2 before age seven than for those who had learned L2 after age seven. No priming effect was observed for the less proficient bilinguals.

COUNTEREVIDENCE

Despite the enduring prominence of the RHM (See Kroll & De Groot, 2005), there have been several studies that have yielded results that are inconsistent with the RHM (Altarriba & Mathis, 1997; Duyck & Brysbaert, 2002; La Heij et al., 1996). For example, Altarriba and Mathis (1997) showed that novice bilinguals could access

conceptual information directly through L2 words. According to the RHM, only proficient bilinguals would be expected to access conceptual information through L2 words directly. In the study, English-speaking participants, who did not know a second language, learned Spanish words. Participants were shown pairs of words, a Spanish word and its English translation equivalent. Participants also heard the Spanish word pronounced and then completed simple sentences using the newly learned words. Following the word-learning phase, participants viewed words presented on a computer and indicated whether a target word was a correct translation of the prime word. The results showed that participants had slower reaction times for L2 target words when they were presented with semantically related L1 primes words (e.g., *manzana* paired with *grape*) than with the correct L1 translation prime words (e.g., *manzana* paired with *apple*). No difference in translation time would be expected to be observed when a novice bilingual translates L2 words into L1. Altarriba and Mathis (1997) argued that when L2 words are learned very well initially, memory links to conceptual representation can develop rapidly.

In a study investigating processing by highly proficient Dutch-English bilinguals, La Heij et al. (1996) showed that categorical interference can occur for words translated from L2 to L1, rather than only for L1 to L2, as observed by Kroll and Stewart (1994). In the first of two central experiments, Dutch-English bilinguals translated words presented either in random order or blocked by semantic category. Words were presented either with a congruent picture (e.g., the word *fork* would be paired with a picture of a *fork*) or incongruent picture (e.g., the word *fork* paired with a picture of a *dog*). Translations times were expected to be influenced by the relatedness between the word and the

picture. This prediction was supported, as translation times were slower in congruent picture conditions than in incongruent pictures. More importantly, the results also showed that L2 to L1 translation was slower than L1 to L2 translation, which was not expected following the RHM. Kroll and Stewart (1994) observed the opposite pattern of results. In the second experiment, La Heij et al. (1996) substituted the congruent and incongruent pictures with ones that were either semantically related (e.g., the word *fork* paired with the picture of a *spoon*) or semantically unrelated (e.g., the word *fork* paired with a picture of a *dog*). The results again showed that words were translated slower when they were paired with a semantically related picture than when they were paired with a semantically unrelated picture. Participants were also faster to translate L1 to L2 than L2 to L1 direction.

Most recently, Duyck and Brysbaert (2002) tested a group of highly proficient Dutch-French bilinguals and showed that the time to translate from L2 to L1 was not always faster than L1 to L2, as predicted by the RHM. In this experiment, participants viewed Arabic digits (e.g., *3*) followed by a target stimulus that could either be an Arabic digit, a number word from their L1, or a number word from their L2. Participants were instructed to translate as quickly as possible the target item into the opposite language. The results indicated that when participants translated target items, translation times were slower for L2 to L1 translations than for L1 to L2 translations. According to the RHM, priming for concepts (i.e., pictures or numbers) was expected to be slower for L1 to L2 than for L2 to L1 because the former has direct access to the memory component in which concepts are stored. This finding led the authors to conclude the revised

hierarchical model has underestimated the extent to which L2 to L1 translation can be influenced by conceptual-level processing.

AGE OF ACQUISITION

Despite the growing evidence supporting the RHM, the studies in which contradictory results have been obtained suggest that bilingual memory representations are still not completely understood. The purpose of the present research was to investigate the possibility that the conflicting results in prior research are attributable, at least in part, to the fact that the materials in the studies did not control a critical variable -- age of acquisition. The term age of acquisition (AoA) has been used to refer to the approximate age at which specific words are learned. Research on AoA began in the early 1970s with the seminal work of Carroll and White (1973) and Gilhooly and Gilhooly (1979). These researchers showed that participants processed words learned early in childhood faster than words learned later in childhood. More recent studies have found age of acquisition effects in a variety of language processing tasks, including lexical decision (Morrison & Ellis, 2000; 1995; Stadthagen-Gonzalez, Bowers, & Damian, 2004), semantic categorization (Brysbaert et al., 2000; Ghyselinck, Custer, & Brysbaert, 2004), picture naming (Ellis & Morrison, 1998; Morrison, Ellis, & Quinlan, 1992), word naming (Brown & Watson, 1987; Morrison & Ellis, 2000; 1995**),** silent word reading (Zevin & Seidenberg, 2002), and fixation durations during sentence processing (Juhasz & Rayner, 2004).

Recently, researchers investigating bilingual language processing have also recognized that AoA may influence bilingual language processes (Hirsh, Chapell, & Ellis, 2002; Hirsh, Morrison, Gaset, & Carnicer, 2003; Izura & Ellis, 2004). However, no previous study has investigated the possible role of AoA in explaining the conflicting results of Kroll and Stewart (1994), La Heij et al. (1996) and Duyck and Brysbaert (2002). When one reviews the materials from these studies, one finds that there are differences in the numbers of items used and in the overall AoA of the items. Kroll and Stewart (1994), who observed categorical interference only for L1 to L2 (i.e., slower translation times when items were blocked by semantic category than when items were presented in random order), used the largest number of items (i.e., 144), many of which appear to be high AoA words. La Heij et al. (1996), who observed categorical interference occurring in the opposite direction as that observed by Kroll and Stewart (1994), used relatively few items (i.e., 30), most of which appear to be low AoA words. Duyck and Brysbaert (2002), who also observed categorical interference occurring in the same direction as observed by La Heij et al. (1996), used numbers and number words, most of which appear to be low AoA words. Classifications of these prior materials were carried out using the ratings reported by Gilhooly and Logie (1980) and by ratings obtained in the present research. Appendix A contains a complete list of words that were used in these three studies.

RESEARCH HYPOTHESIS

The experiment described in this paper tested the hypothesis that AoA plays an important role in bilingual memory representation. Specifically, it was hypothesized that

memory links between conceptual memory and low AoA L1 words were expected to be stronger than memory links between conceptual memory and high AoA L1 words. The experiment reported in this paper employed a design similar to the one used by Kroll and Stewart (1994). Spanish-English bilinguals for whom Spanish was a first language viewed a series of words and were instructed to translate each word into the opposite language as quickly as possible. Three factors were co-varied in the experiment: 1) direction of translation; 2) AoA; and 3) order or presentation. As in Kroll and Stewart (1994), participants translated words that were blocked by semantic category or randomized. Low AoA words were expected to be translated faster than high AoA words. Furthermore, following the view that memory links between low AoA words and conceptual representation are stronger than memory links between high AoA words and conceptual representation, categorical interference was expected to be observed to a greater extent in low AoA conditions than high AoA conditions. On the other hand, if AoA is not related to differences in the strengths of memory links between words and conceptual representations, then the results were expected to be consistent with either Kroll and Stewart's (1994) or La Heij et al.'s (1995) results. Following Kroll and Stewart (1994), categorical interference was expected to be observed when participants translated L1 words into L2, but not when participants translated L2 words into L1. Following La Heij et al. (1996), L2 to L1 translation is expected to be slower than L1 to L2 when participants translated in categorically blocked conditions than when participants translated in randomized conditions.

CHAPTER III

METHODOLOGY

PARTICIPANTS

Thirty-six highly proficient Spanish-English bilinguals for whom Spanish was the first language were recruited from the campus of Oklahoma State University and surrounding communities. Most participants were foreign language instructors, translators, or graduate students. There were 22 females and 14 males with an average age of 30.7 (*SD*=13.5). Participants were asked "at what age did they begin learning English." The average age reported was seven years old (*SD*= 5.5, min= birth, max= 18 years old). The participants also provided proficiency ratings for their ability to speak, read, write, and understand Spanish and English. The scale for the proficiency-rating questionnaire ranged from 1-to-7 ("1" indicated poor and "7" indicated excellent). A summary of participants' mean proficiencies in English and Spanish are displayed in Table 1.

MATERIALS

One hundred twenty items were used, representing six semantic categories: (1) animals; (2) body parts; (3) clothing; (4) kitchen items; (5) foods; and (6) numbers. In each category, 20 pairs of words (i.e., an English word and the matching Spanish translation equivalent) were used in the experiment. Only words with one dominant translation equivalent were selected. Efforts were made to use only word pairs that were orthographically dissimilar (i.e., non cognates). Using words that are orthographically

similar to words in the opposite language might have led to confusion, as participants may have had difficulty identifying which language to use for the response. Words were selected using results of a preliminary norming study. Candidate words were selected from Gilhooly and Logie (1980) and from word lists generated from Francis and Kučera (1982). A normative rating study was carried out to make the final selections. Normative ratings for the age of acquisition classifications were obtained using a methodology similar to that used by Gilhooly and Logie (1980). Twenty English monolinguals and 20 native speakers of Spanish, with low levels of English proficiency provided age of acquisition ratings for a list of 251 words. For each word, participants rated on a scale from 1-to-7, when they had learned the word. On this scale, "1" indicated that they had learned the word prior to the age of 2 and "7" indicated that they had learned the word during the age range of 13 and onward. The interval points on the scale represented a 2-year age range. Ratings for English words were obtained from the native speakers of English. Likewise, the ratings for Spanish words were obtained from the native speakers of Spanish. Of the words used in the translation experiment, the low age of acquisition category had a mean age of acquisition rating of 2.13 (*SD*= .47) and the low age of acquisition Spanish translation equivalents had a mean age of acquisition of 2.33 (*SD*= .60). In terms of years, a rating of "2" is equivalent to the age range from 3 to 4 years old. The high age of acquisition English words had a mean age of acquisition rating of 3.94 (SD= .78) and the high age of acquisition Spanish translation equivalents had a mean age of acquisition of 3.94 (SD= .80). In terms of years, a rating of "4" is equivalent to the age range from 7 to 8 years old. Appendix B contains a complete list of the words that were used in the experiment. English words and their Spanish translation

equivalents were closely matched on length. Words in the low age of acquisition category were comparable to words in the high age of acquisition category in terms of mean number of syllables in English (low AoA: 1.25 vs. high AoA: 1.70) and in Spanish (low AoA: 2.30 vs. high AoA: 2.58), in terms of mean number of printed characters in English (low AoA: 4.53 vs. high AoA: 5.47) and in Spanish (low AoA: 5.42 vs. high AoA: 6.22). Words in both the low and high age of acquisition categories were matched on printed frequency in English, as assessed by Francis and Kučera (1982), and in Spanish, as assessed by Sebastián-Gallés, Cuetos-Vega, Carreiras-Valiña, and Martí-Antonin (2000). The frequency matching was challenging because many of the low AoA items had higher word frequencies than the high AoA items. For items in the number category, all words were high frequency. For items in the remaining categories, all words were low frequency. Table 2 displays a summary of the mean frequencies for low and high AoA conditions by language.

APPARATUS

Stimulus presentation and collection of responses were performed by a Toshiba Satellite A75 laptop computer with a 15 inch viewing screen controlled by E-Prime (version 1.1 Beta 1.0, Schneider, Eschmann, & Zuccolotto, 2002). Response times were recorded using a Model 300 Serial Response Box (from Psychology Software Tools) with an ATR 20C Audio-Technica microphone. All words were displayed in white lowercase letters on a black background.

PROCEDURE

Participants were instructed to translate each word into the opposite language as quickly as possible. Participants were informed about the importance of enunciating clearly during the task and to avoid saying "uhm" before producing the response. Participants were also instructed to say, "don't know" if they did not know an equivalent translation for the presented word. All participants began with a practice block of 20 items in order to familiarize themselves with the task. None of the words in the practice block were used in the subsequent experiment. The experimental task involved participants viewing two sets of trials. One set of trials was presented in random order and the other set of trials was blocked by semantic category. Half of the participants received the randomized trials first, and half received the blocked trials first. Both of the blocked set of trials, contained words from each of the six semantic categories, half of which were English words and half were Spanish words. Within a set of trials, half of the trials involved a Spanish word for which the participant would produce the English translation. Half of the trials involved an English word for which the participant would produce the Spanish translation. Within a set of trials, a particular concept was presented just once. For this second set of trials, participants viewed the translation equivalents of those words viewed during the first block. For words that appeared in Spanish in the first set of trials, the English translation equivalent appeared in the second set of trials. For words that appeared in English in the first set of trials, the Spanish translation equivalent appeared in the second set of trials. Four counterbalancing lists were used in order to ensure that each

Spanish word and English word appeared equally often in a first or second set of trials and in each type of presentation order. Participants were randomly assigned to one of the four counterbalancing lists. All counterbalancing lists contained an equal number of participants. At the end of the session, all participants completed a language history survey, which is provided in Appendix C.

CHAPTER IV

FINDINGS

Response times were eliminated for trials on which 1) participants responded incorrectly (on 306 of the 8640 trials which was 3.5% of the overall dataset); 2) participants responded with "don't know" (on 713 trials which was 8.3% of the overall dataset); 3) participants triggered the voice key prematurely (i.e., within 100 milliseconds following the presentation of the target word) (on 90 trials which was 1% of the overall dataset); and 4) participants hesitated during speaking and produced as response time longer than 2500 milliseconds (on 958 trials which was 11.1% of the overall dataset). [1] Mean response times and standard errors for the remaining 6573 trials were calculated for each condition. Means and standard errors are displayed in Table 3 and in Figure 2. Mean response times were analyzed in analyses of variances (ANOVAs) in which participants (F1) and items (F2) were treated as random effects, following Clark (1973). The three within-participant factors were 1) AoA; 2) direction of translation; and 3) order of presentation.

A series of planned comparisons were conducted to investigate the effects of AoA, direction of translation, and order of presentation on translations times. These comparisons showed that high age of acquisition words took longer to translate than low age of acquisition words (1556 ms vs 1357 ms, respectively), $F_1(1,35)=322.08$, $MSe=8797$, $p < .001$, $\eta^2= .90$, $F_2(1,59)=41.96$, $MSe=241762$, $p < .001$, $\eta^2= .42$, and

showed that participants were slower to translate from L1 to L2 than L2 to L1 (1485 ms vs 1428 ms, respectively), $F_1(1,35)=4.55$, $MSe=51876$, $p < .05$, $\eta^2 = .12$, $F_2(1,59)=5.93$, $MSe=38692$, $p < .05$, $\eta^2 = .07$. Lastly, categorical interference (i.e., longer translation times when trials were blocked by semantic category than when trials were presented in random order) was observed only in low age of acquisition conditions when participants translated from L1 to L2, $F_1(1,35)=4.69$, $MSe=10763$, $p < .05$, $\eta^2 = .12$, $F_2(1,59)=6.85$, $MSe=11817$, $p < .05$, $\eta^2 = .11$; categorical interference was not observed in the three remaining pairs of conditions, Fs < 1.

CHAPTER V

CONCLUSION

The results of the present research demonstrated that age of acquisition influences performance in a bilingual translation task. Words learned later in life took longer to translate than words learned earlier in life. Furthermore, categorical interference (i.e., longer response time when trials were blocked by semantic category than when trials were presented in random order) was observed only when participants translated Spanish low AoA words into English (i.e., L1 to L2). The results suggest that memory links between L1 words and the conceptual representation are stronger for low AoA words than high AoA words.

The pattern of results differs from the results obtained in studies conducted by Kroll and Stewart (1994), La Heij et al. (1996) and Duyck and Brysbaert (2002), which did not manipulate or control for AoA. Following Kroll and Stewart (1994), categorical interference was expected to be observed when participants translated L1 words into L2, but not when participants translated L2 words into L1. The present results supported Kroll and Stewart's (1994) observations by finding evidence that when participants translated words blocked by semantic category there were slower translation times (i.e., categorical interference) for L1 to L2 but not for the L2 to L1 direction. However, contrary to Kroll and Stewart's findings, the present study did not observe categorical interference for all of the L1 to L2 conditions. The present study found slower translation

times for the trials containing low AoA words and not the high AoA words. It is likely that Kroll and Stewart's (1994) previous results were observed because their materials included a large number of high AoA words. Because Kroll and Stewart (1994) lost a large percentage of the dataset either because participants' responded in error or took too long to respond, it is possible that more data was lost for high AoA words than low AoA words. For these reasons, the L1 to L2 conditions of Kroll and Stewart (1994) results can be viewed as comparable to the L1 to L2 low AoA conditions of the present experiment. To accommodate the present results, the RHM can be minimally revised to include the assumption that AoA influences the strength of memory links between individual words and conceptual representations. Figure 3 displays a suggestion for a proposed revision to the RHM.

The present study's results also differed from those results observed by La Heij et al. (1996) and Duyck and Brysbaert (2002). These two studies found that participants took longer to translate L2 to L1 than L1 to L2. Moreover, the materials used in these prior studies were predominately low AoA words. Therefore, it is possible that such results could be obtained because low AoA L1 and L2 words possess very strong memory links to conceptual representations. It is important to note that both of these prior studies employed a different experimental design than the one used by both Kroll and Stewart (1994) and the one used in the present study. La Heij et al.'s (1996) design involved presenting the words with pictures, while Duyck and Brysbaert's (2002) design involved presenting the words with a number digit (e.g., 3). It is possible that the differences between the designs could have contributed to the differences across studies.

The results of this study confirmed the hypothesis that the prior conflicting results were related to differences in AoA. Results showed that low AoA words were translated faster than high AoA words and that categorical interference influenced only L1 to L2 conditions involving low AoA words. These results are consistent with the view that low AoA L1 words have stronger memory links to conceptual representations than either high AoA L1 words or L2 words. To accommodate the present results, the RHM can be minimally revised to include the assumption that memory links between individual words and conceptual representations differ in strength. Figure 3 displays a suggestion for a proposed revision to the RHM.

The proposed revision to the RHM also provides new insight in the results of Altarriba and Mathis (1997) who found that novice bilinguals could activate conceptual information by way of newly acquired L2 words. Because the materials used by Altarriba and Mathis (1997) were exclusively concepts that could be displayed as pictures, they were highly imageable (or concrete). It is likely that these materials were low AoA concepts; thus, the results can be reinterpreted as showing that L2 words referring to low AoA concepts can be learned rapidly in such a way that the L2 word can access meaning directly without having to active the L1 translation equivalent. If this view is correct, then one would expect Altaribba and Mathis's (1997) pattern of results would not be obtained if high AoA concepts were tested; rather, high AoA concepts would be expected to yield results similar to those observed by Kroll and Stewart (1994).

The next step in this program of research is to attempt to replicate these findings in an experiment using the same materials with an additional group of participants, specifically participants who are Spanish-English bilinguals and who learned English as a

first language. The results are expected to show that categorical interference occurs only for low AoA words in the L1 to L2 condition; however, in this new experiment, the items viewed in the L1 to L2 condition would be those items that were in the L2 to L1 condition of the present experiment. This replication would demonstrate that the present results were not observed solely because of some characteristic associated with this sample population of participants.

In sum, the present results show that age of acquisition influences the semantic representations for the bilingual's two languages. Specifically, memory links between conceptual memory and low AoA words in the L1 result in strong categorical interference, whereas high AoA words do not. These results support the view that an asymmetry exists between low and high AoA words. Therefore, this study can be a springboard for guiding our understanding of how AoA works in formulating bilingual memory representations for concepts and lexical items. Understanding the nature of how these memory representations function in both monolinguals and bilinguals is important to the development of future theories of memory. By obtaining such detailed knowledge, it may further contribute to our understanding of how adult memory can be influenced through the learning of a second language later in life.

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APPENDICES

Appendix A

The following words are a categorization of stimuli based on age of acquisition from prior research.

Words from Kroll & Stewart (1994)

Low Age of Acquisition Concepts			*High Age of Acquisition Concepts*		
Knife	Cat	Monkey	Spear	Poison	Missile
Onion	Lettuce	Carrot	Bayonet	Cannon	Mortar
Peas	Potato	Pepper	Whip	Sword	Dagger
Tomato	Horse	Clock	Bomb	Grenade	Pistol
Closet	Stove	Bed	Parsley	Leek	Spinach
Dresser	Desk	Tiger	cabbage	Celery	Rhubarb
Chair	Duck	Chicken	Endive	Asparagus	Beets
Ship	Turkey	Elephant	Cauliflower	Suit	Cabinet
Boots	Hat	Gloves	Ashtray	Curtains	Rocker
Jacket	Coat	Shirt	Bookcase	Blackbird	Stool
Skirt	Shoes	Sweater	Crow	Swan	Eagle
Boat	Dress	Bicycle	Buzzard	Cardinal	Lark
Grape	Lion	Peach	Sparrow	Ostrich	Trousers
Pear	Plum	Apple	Stocking	Tie	Mushroom
Raisin	Banana	Wagon	Blouse	Scarf	Apricot
Train	Rat	Mouse	Fig	Tangerine	Zebra

Dog	Pig	Lemon
Orange	Rabbit	Fox
Sheep	Donkey	Cow

Raspberry	Sandals	Raft
Metro	Motorcycle	Sled
Submarine	Engine	Sailboat
Scooter	Canoe	Camel
Ambulance	Slippers	Tank
Vase	Rocket	Goose
Berry	Arrow	Bricks
Chain	Skates	Rug
Bench	Shelf	Owl
Robin	Parrot	Dove
Deer	Strawberry	Coconut
Grapefruit	Mirror	Rope
Goat	Cherry	Woodpecker

Words from La Heij et al. (1996)

Low Age of Acquisition Concepts			*High Age of Acquisition Concepts*
Bag	Tree	Watch	axe
Boot	Lemon	Turtle	iron
Bottle	Leg	Thumb	lighter
Cake	Key	Stove	trousers
Car	Kite	Spoon	Shark
Carrot	Glove	Rabbit	Nail

Chair	Dog	Paper
Church	Deer	Window

Words from Duyck and Brysbaert (2002)

Low Age of Acquisition Concepts			*High Age of Acquisition Concepts*
One (1)	Two (2)	Three (3)	Eleven (11)
Four (4)	Five (5)	Six (6)	Twelve (12)
Seven (7)	Eight (8)	Nine (9)	
Ten (10)			

Appendix B

The following contains all of the words that will be used in the experiment. The words are displayed by semantic category. There are six semantic categories (i.e., animals, body parts, clothing, kitchen items, parts of a house, and numbers). For each category, ten concepts that are low in age of acquisition and ten concepts that are high in age of acquisition are presented. An English words and a Spanish translation is listed for each concept.

Animals

Low Age of Acquisition Concepts		High Age of Acquisition Concepts	
squirrel	ardilla	whale	ballena
sheep	oveja	octopus	pulpo
rooster	gallo	swan	cisne
turtle	tortuga	lizard	lagarto
worm	gusano	raccoon	mapache
mouse	ratón	beaver	castor
monkey	mono	ape	simio
frog	rana	walrus	morsa
rabbit	conejo	moose	alce
pig	cerdo	weasel	comadreja

Body Parts

Low Age of Acquisition Concepts		High Age of Acquisition Concepts	
mouth	boca	heart	corazón
nose	nariz	ankle	tobillo
elbow	codo	blood	sangre
toe	dedo	skin	piel
tongue	lengua	jaw	mandíbula
thumb	pulgar	brain	cerebro
ear	oreja	hip	cadera
lip	labio	liver	hígado
leg	pierna	lung	pulmón
tooth	diente	chest	pecho

Clothing

Low Age of Acquisition Concepts		High Age of Acquisition Concepts	
shoe	zapato	scarf	pañuelo
diaper	pañal	vest	chaleco
dress	vestido	gown	bata
shirt	camisa	suspenders	tirantes

pants	pantalón	garter	prenda
bib	babero	tie	corbata
boots	botas	veil	velo
gloves	guantes	bra	sostén
belt	cinturon	girdle	faja
socks	calcetín	shawl	chal

Kitchen items

Low Age of Acquisition Concepts		High Age of Acquisition Concepts	
fork	tenedor	teapot	tetera
plate	plato	ladle	cucharón
cup	taza	freezer	congelador
towel	toalla	apron	delantal
spoon	cuchara	cupboard	aparador
lid	tapa	carafe	garrafa
broom	escoba	whisk	batidor
pot	olla	faucet	grifo
oven	horno	skewer	pincho
napkin	servilleta	mop	fregona

Foods

Low Age of Acquisition Concepts		High Age of Acquisition Concepts	
cookie	galleta	cucumber	pepino
milk	leche	turnip	nabo
juice	jugo	watermelon	sandía
cheese	queso	stew	guisado
banana	platano	steak	bistec
apple	manzana	cranberry	arandano
egg	huevo	fig	higo
corn	maíz	beer	cerveza
pea	guisante	cabbage	repollo
grape	uva	wine	vino

Numbers

Low Age of Acquisition Concepts		High Age of Acquisition Concepts	
one	uno	fourteen	catorce
two	dos	fifteen	quince
three	tres	thirty	treinta

four	cuatro	twenty	veinte
five	cinco	forty	cuarenta
six	seis	sixty	sesenta
seven	siete	fifty	cincuenta
eight	ocho	seventy	setenta
nine	nueve	hundred	cien
ten	diez	thousand	mil

Appendix C

The following contains the language proficiency questionnaire that was used in order to assess the language proficiency of each participant.

1. At what age did you begin learning Spanish? (If from birth, write in "from birth").

2. At what age did you begin learning English? (If from birth, write in "from birth").

3. My ability to speak Spanish is…

Poor						Excellent
1	2	3	4	5	6	7

4. My ability to read Spanish is…..

Poor						Excellent
1	2	3	4	5	6	7

5. My ability to write in Spanish is….

Poor						Excellent
1	2	3	4	5	6	7

6. My ability to understand conversational Spanish is…

Poor						Excellent
1	2	3	4	5	6	7

7. My ability to speak English is…

Poor						Excellent
1	2	3	4	5	6	7

8. My ability to read English is…..

Poor						Excellent
1	2	3	4	5	6	7

9. My ability to write in English is….

Poor						Excellent
1	2	3	4	5	6	7

10. My ability to understand conversational English is…

Poor						Excellent
1	2	3	4	5	6	7

11. Please describe the activities that you used to learn Spanish (school, home, friends, etc.)?

12. Please describe the activities that you used to learn English (e.g., school, home, friends, etc.)?

13. Where were you born (city, state, country)? _____

In what other places did you spend time during your childhood (list places that you lived for a year or more).

14. In the average week, what percentage of your time is spent using English (reading, writing, talking, etc.)? _____

15. In the average week, what percentage of your time is spent using Spanish (reading, writing, talking, etc.)? _____

16. If given the option to receive printed material in either Spanish or English, which would you prefer?

Spanish_____ English_____

17. How old are you (in years)?_____

18. Are you male or female (check one): _____male _____female

Footnote

[1] The data trimming procedures for this study was comparable to prior studies. The overall percentage of data trials that were trimmed in the Kroll and Stewart (1994) study was 52.12%. Likewise, for the La Heij et al. (1996) study, 18.5% of the overall data was trimmed.

Table 1

Summary of mean proficiency (SD) in Spanish and English for participants in the translation experiment.

Language Skill	Spanish	English
Speaking	6.40 (0.64)	6.00 (1.00)
Reading	6.50 (0.58)	6.20 (1.00)
Writing	6.00 (0.90)	6.00 (1.00)
Conversational Skills	6.70 (0.70)	6.20 (0.91)

Table 2

Summary of mean frequency (SD) for English and Spanish words used in the Experiment.

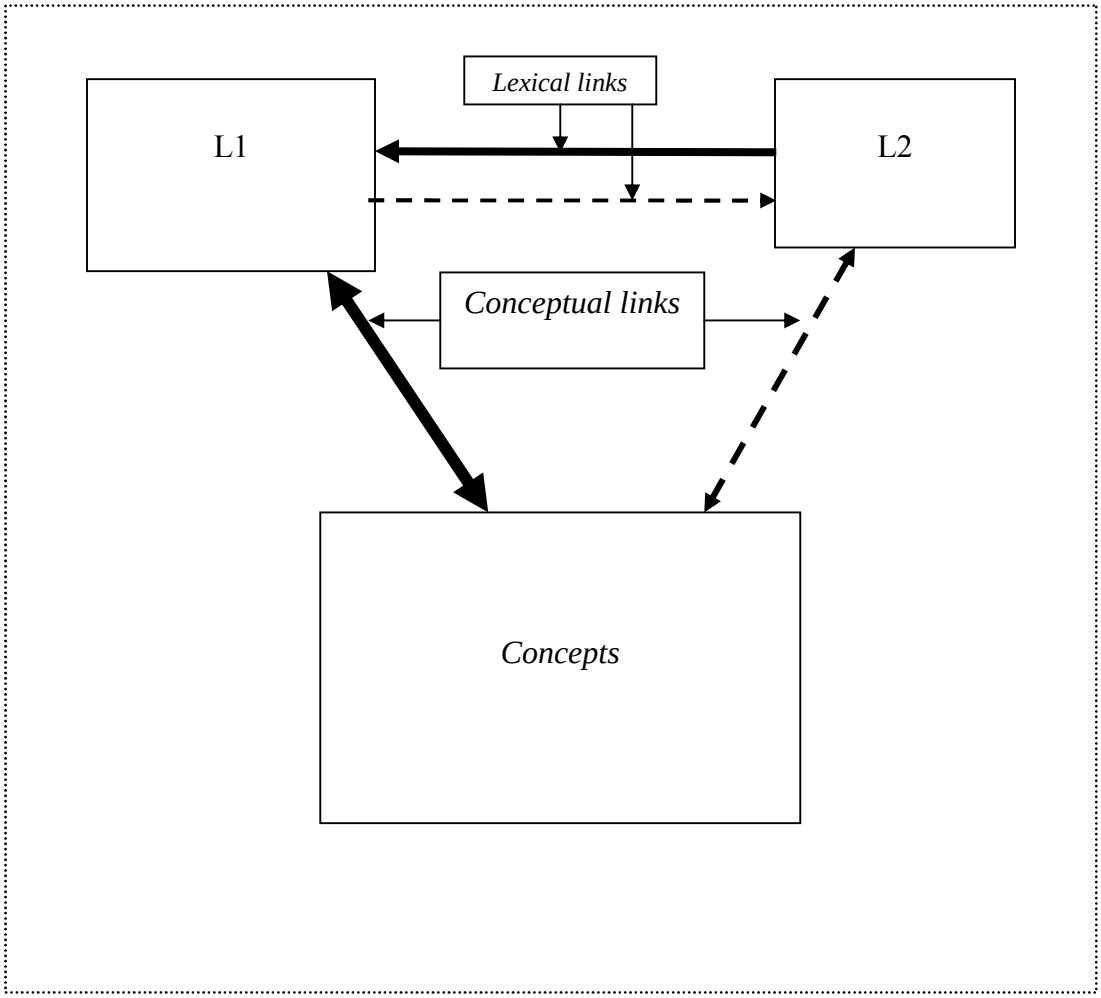
	Low AoA Condition	*High AoA Condition*
Category	Mean Frequency in English	Mean Frequency in English
Animals	11 (7)	2 (1)
Clothing	16 (17)	7 (9)
Food	17 (15)	16 (30)
Kitchen items	22 (18)	3 (12)
Body parts	68 (43)	60 (58)
Numbers	609 (848)	65 (58)

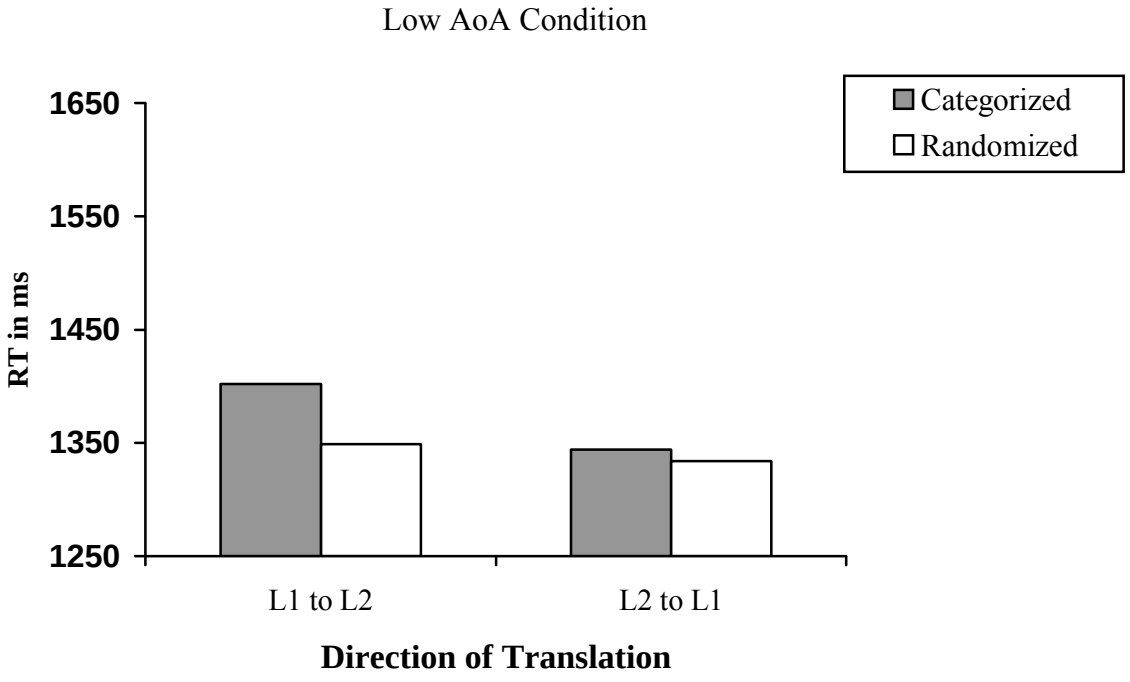
	Low AoA Condition	*High AoA Condition*
Category	Mean Frequency in Spanish	Mean Frequency in Spanish
Animals	10 (10)	2 (1)
Clothing	15 (15)	10 (6)
Food	14 (15)	16 (40)
Kitchen items	9 (9)	2 (6)
Body parts	44 (49)	66 (68)
Numbers	385 (406)	63 (54)

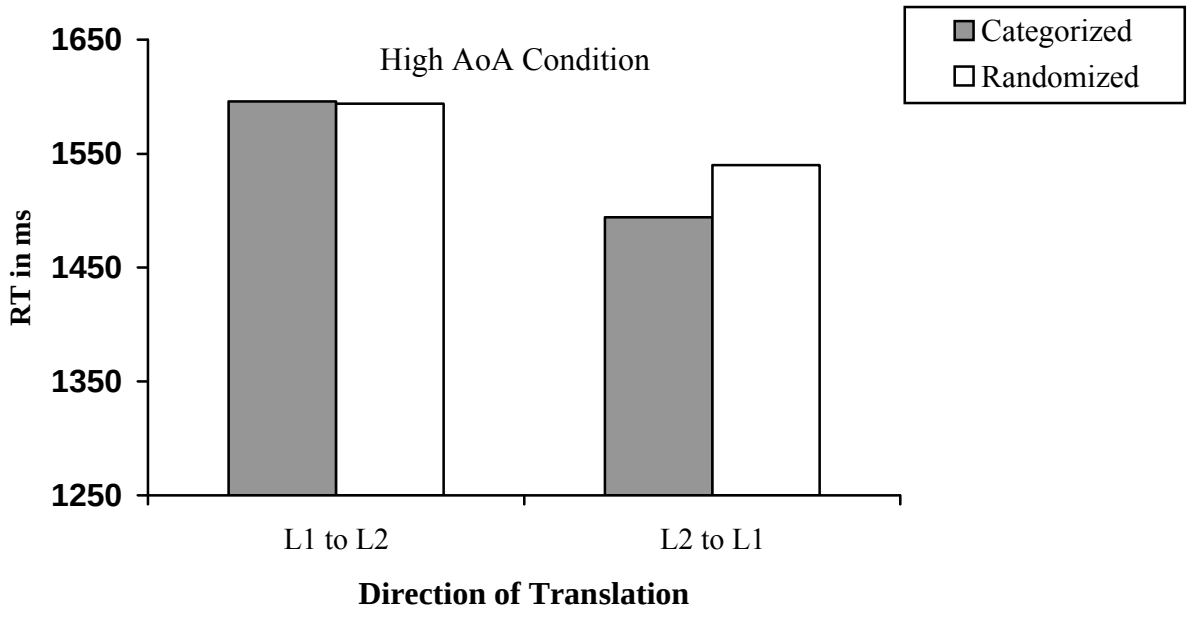
Table 3

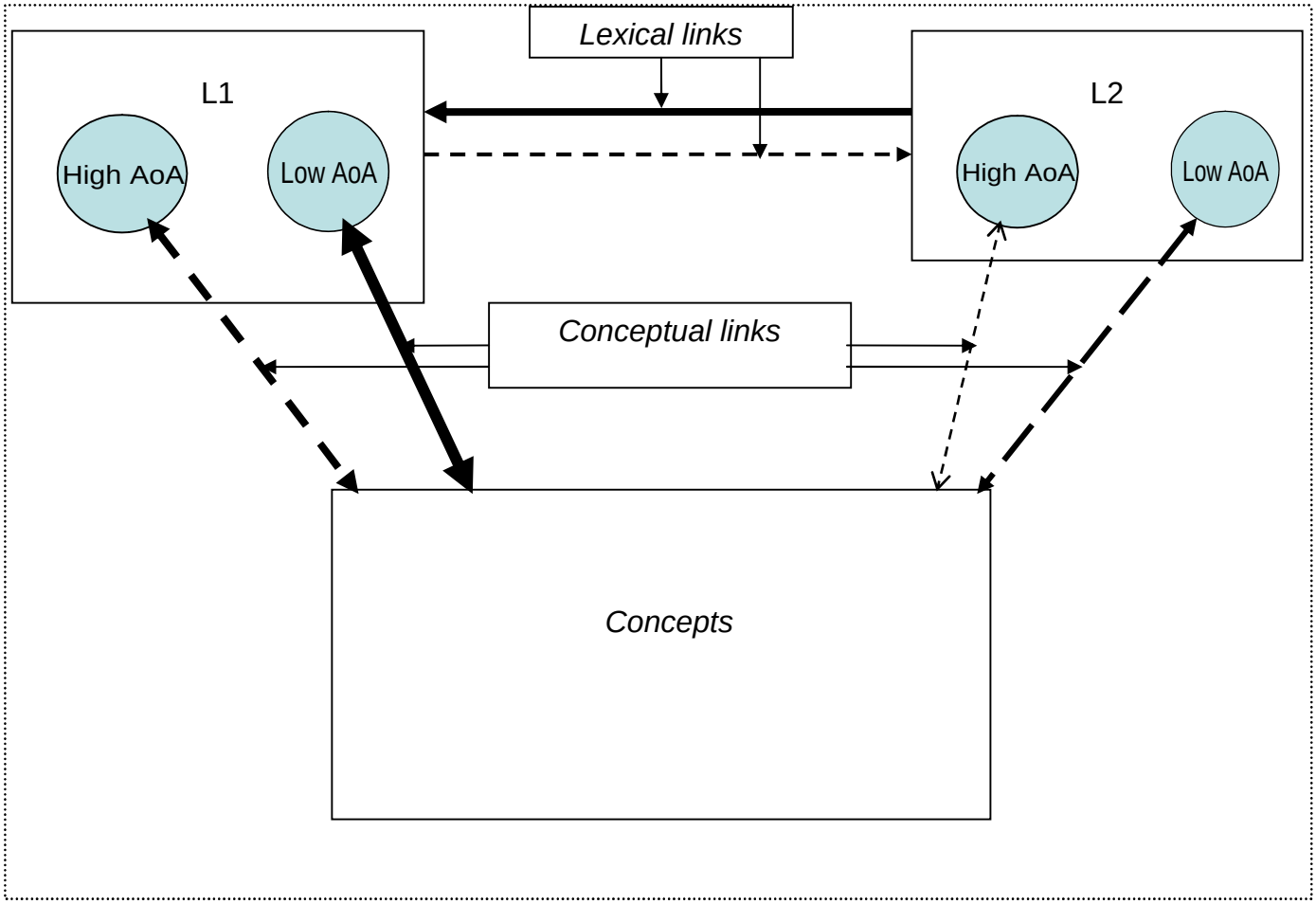
Summary of mean response times (SE) for low and high AoA words by condition.

	L1 to L2 Condition		L2 to L1 Condition	
	Categorized	Randomized	Categorized	Randomized
Low AoA	1402 (41)	1349 (43)	1344 (37)	1334 (47)
High AoA	1596 (42)	1594 (50)	1494 (43)	1540 (43)


Lexical links
L1
L2
Conceptual links
Concepts


Low AoA Condition
Categorized
Randomized
1650
1550
1450
1350
1250
RT in ms
L1 to L2
L2 to L1
Direction of Translation


Categorized
Randomized
High AoA Condition
1650
1550
1450
1350
1250
RT in ms
L1 to L2
L2 to L1
Direction of Translation


Lexical links
L1
High AoA
Low AoA
L2
High AoA
Low AoA
Conceptual links
Concepts

CONSENT FORM

A. AUTHORIZATION

I, _____ (respondent), hereby authorize J. Michael Bowers and Dr. Shelia M. Kennison to perform the following treatment or procedure.

B. DESCRIPTION

I understand that the research study is entitled Bilingual Word Translation and is being conducted in the Department of Psychology at Oklahoma State University. I understand that the purpose of the research is to understand basic memory processing in speakers knowing more than one language. I understand that I will complete a language history questionnaire on which I will describe my language proficiency and my prior language learning experiences. I understand that I will participate in a computerized task in which I will view words in Spanish and English and will be asked to translate each word into the opposite language. I understand that after the computer task I will complete a short word rating questionnaire. I understand that the computer will record how quickly I translate each word. The session is expected to last less than 90 minutes.

I understand that there are no known or foreseeable risks and no foreseeable discomfort to participants in this study beyond that expected in daily life.

I understand that I am not expected to benefit in any way. However, society may benefit one day, if the results lead to better understanding of how language is processed.

I understand that my name and responses in this study will not be stored together in any permanent record, and that my responses will be kept confidential.

I understand that any question regarding this study can be directed to J. Michael Bowers, Department of Psychology, 215 North Murray, Oklahoma State University, Stillwater, Ok. 74078 or Dr. Shelia Kennison, Department of Psychology, 215 North Murray, Oklahoma State University, Stillwater, OK 74078. Phone: 405-744-7335.

I understand that any question regarding my rights as a research participant can be directed to Dr. Sue Jacobs, the IRB Chair, 744-1676, Oklahoma State University, 415 Whitehurst, Stillwater, OK 74078.

C. VOLUNTARY PARTICIPATION

I understand that participation is voluntary and that I will not be penalized if I choose not to participate. I also understand that I am free to withdraw my consent and end my participation in this project at any time without penalty, after I notify the project director.

D. CONSENT

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: _____ Time: _____(a.m./p.m.)

Signed:

Signature of person authorized to sign for subject, if required

OSU
Institutional Review Board
Approved 3/21/05
Expires 3/20/06
Initials DJ
AS0564

VITA

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Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: AGE OF ACQUISITION EFFECTS IN BILINGUAL WORD TRANSLATION

Pages in Study: 46

Candidate for the Degree of Master of Science

Major Field: Psychology

Scope and Method of Study: Empirical Research

Findings and Conclusions:

The present research investigated the organization of semantic memory in bilinguals. Prior research suggested that memory links between conceptual representations and words in one's first language (L1) are stronger than memory links between conceptual representations and words in one's second language (L2). The present research tested the hypothesis that memory links between conceptual representations and L1 words are stronger for words learned early in life than words learned later in life. An experiment with 36 Spanish-English bilinguals supported the hypothesis. Participants translated L1 words into L2 and L2 words into L1 when target words were presented either in random order or blocked by semantic category. Half the words were learned early in childhood (low AoA words), and half were learned later in life (high AoA words). Implications for current models of bilingual memory are discussed.

ADVISER'S APPROVAL: Dr. Shelia Kennison